Planning a new ski lift system in Sisimiut (Greenland)

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ARCTIC TECHNOLOGY CENTRE

Planning for a new ski lift system in Sisimiut (Greenland)

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Introduction

1. **Sisimiut**
   5.900 inhabitants (Greenland 55.000 inhabitants)

   Second largest city in Greenland

   Fishing Industry

   Important touristic highlight in Greenland

Introduction

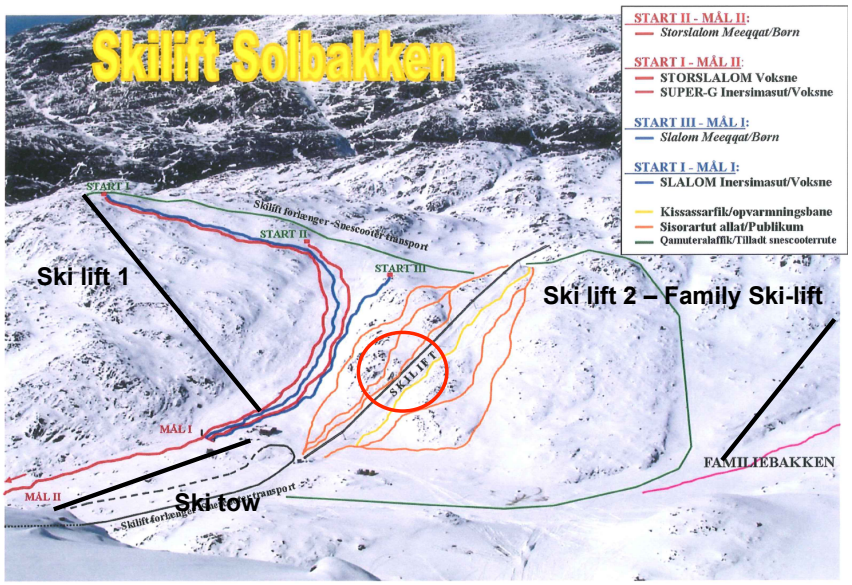
2. Igloo Mountain Project

Solbakken Actual Situation

Introduction

2. Igloo Mountain Project

Solbakken Actual Situation

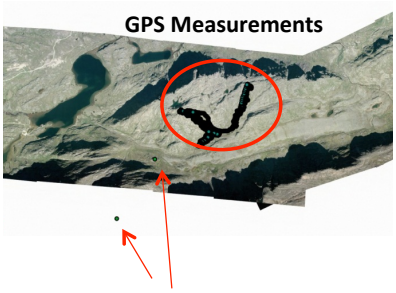


State of The Art

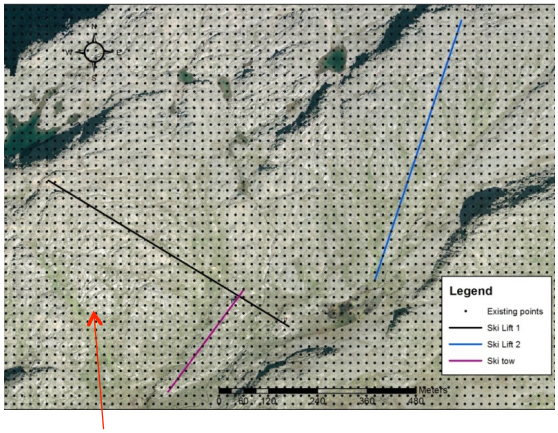
1. DEM Creation

-From the National Survey and Cadastre of Denmark a list with more than 8000 points was obtained.

-In 2006 ortophotos were taken between the 130 kilometers that separate Sisimiut and Kangerlussuaq.



Source: National Survey and Cadastre of Denmark



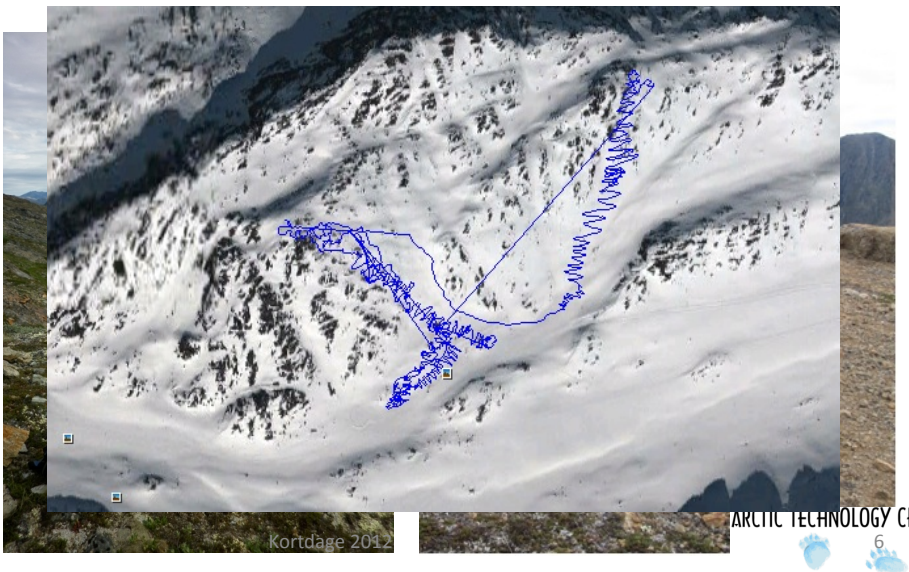
20 meters size grid

Fieldwork

What was done?

1. GPS Measurements

- Kinematic Survey was realized to obtain more altitude data in the zone of interest.



Fieldwork

What was done?

2. Geological Survey

1. **Characterization of rock samples**

   a. *Lithology and Meteorization.*

   b. *Physical and Mechanical Properties:* Point Load Index Test were realized

Altitude	Bottom	Middle	Top
σc (Mpa)	69	113	32

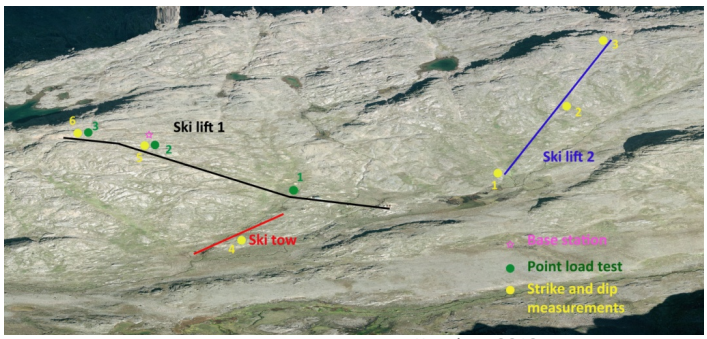
2. **Description of discontinuities**
   a. *Orientation*
   b. *Spacing*
   c. *Discontinuity length*
   d. *Roughness*
   e. *Aperture and Infilling*
   f. *Groundwater conditions*

Fieldwork

What was done?

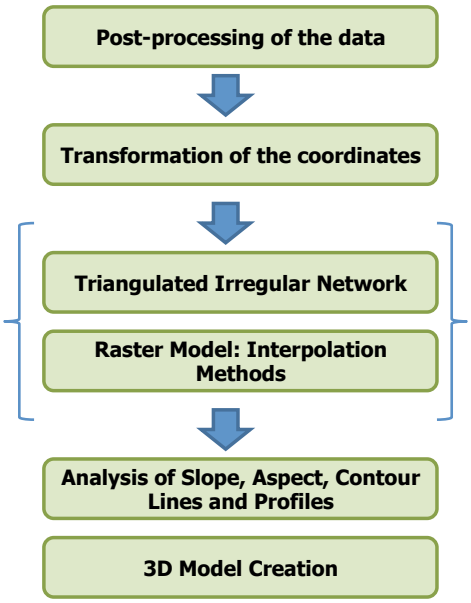
3. Rock Mass Classification

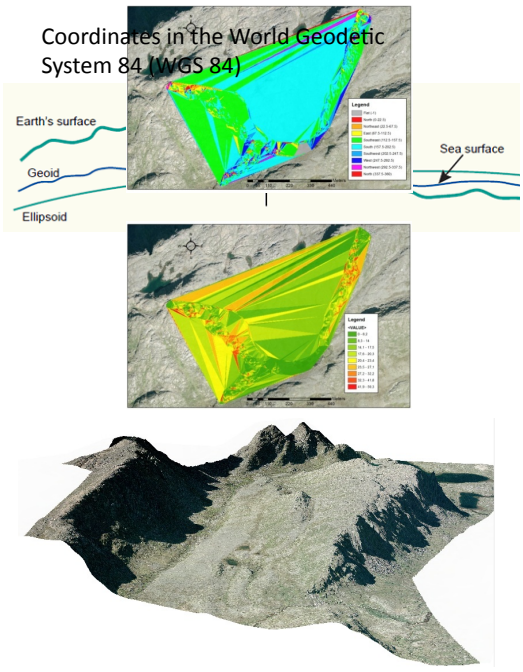
Altitude	RMR	RMR significance	Q Index	Q Index significance
Bottom	62	Medium quality	12,5	Medium quality
Midlle	67	Medium quality	5,95	Medium quality
Top	52	Medium or fair quality	0,53	Very bad quality



Analysis and Results

1. DEM Creation and Analysis





Analysis and Results

3. GIS-Based Kinematic Slope Stability Analysis

3.1. Reasons to use this type of analysis

- More detailled analysis of the rock slope failure, since no general characterizations are done
- Easiness to rapidly analyze all the slopes of a big area

3.2. Methodology

- Introduction of all the geological characteristics used in the kinematic analysis in the DEM as raster data
- Use of the Raster Calculator Tool from ArcGIS to compare different values of raster files

3.3. Results

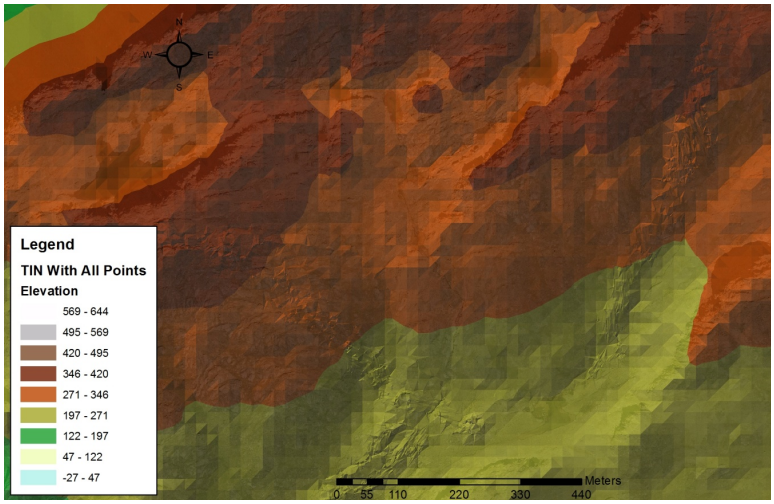
-Very similar to the ones obtained in the traditional kinematic analysis.

Analysis and Results

1. DEM Creation and Analysis

1. TIN: Triangulated Irregular Network

TIN Model Considering the Existing Points

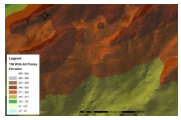


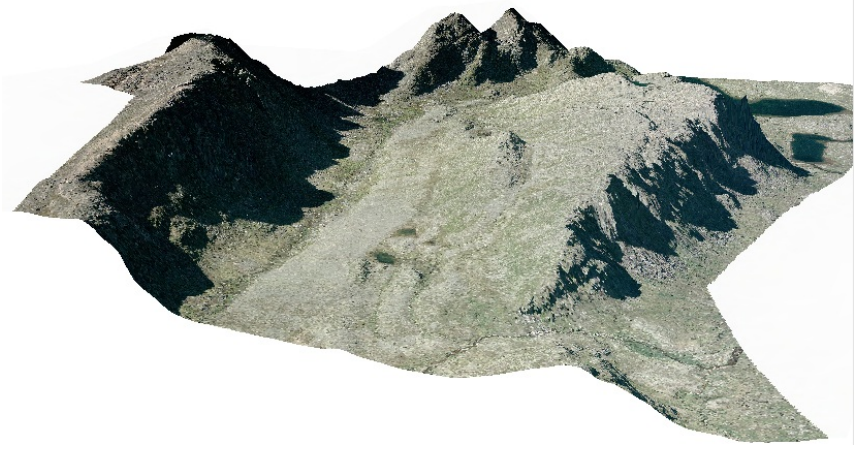
Analysis and Results

1. DEM Creation and Analysis

1. TIN: Triangulated Irregular Network

TIN Model Considering the Existing Points



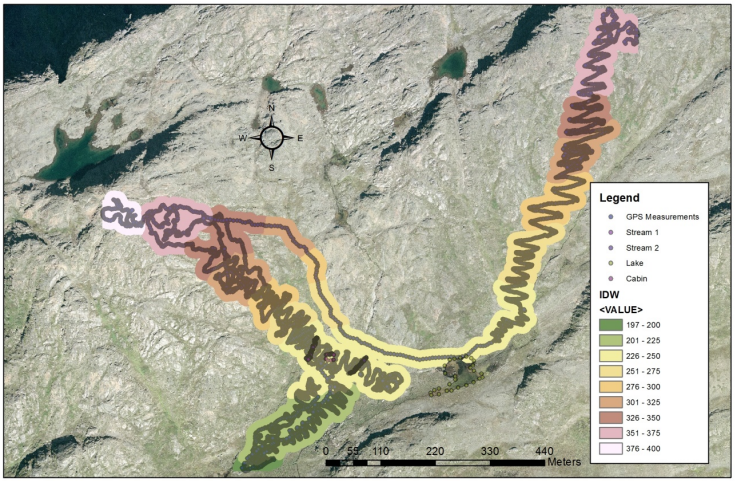


Analysis and Results

1. DEM Creation and Analysis

2. Raster Model

Inverse Distance Weighting with p=2.7



Analysis and Results

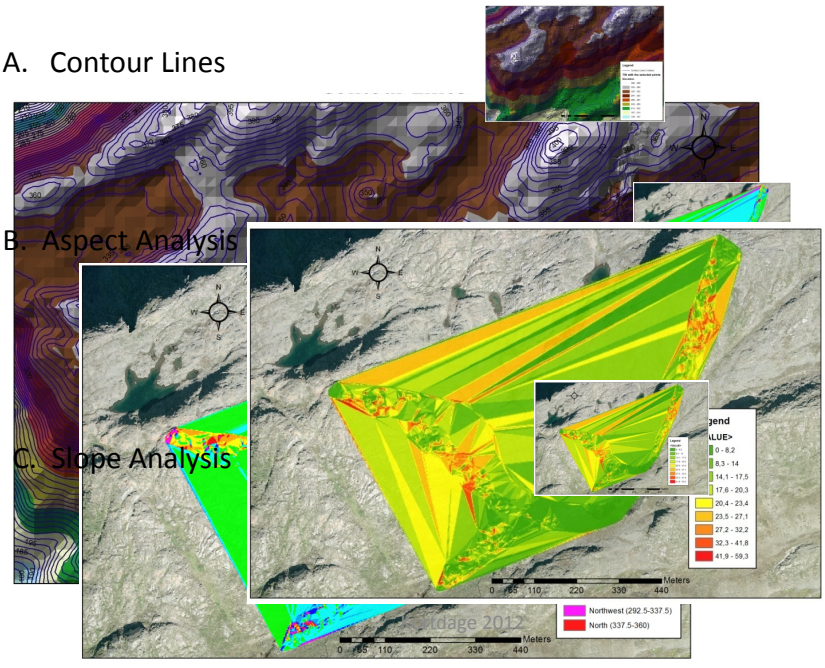
1. Digital Elevation Model Creation and Analysis

3. Contour Lines, Aspect and Slope Analysis

A. Contour Lines

B. Aspect Analysis

C. Slope Analysis

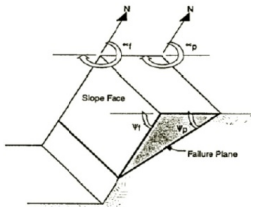


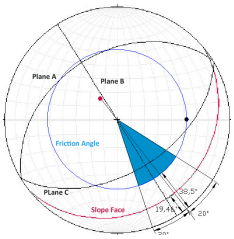
Analysis and Results

2. Kinematic Analysis of Rock Slope Failure

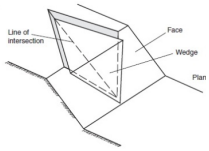
2.3. Failure Analysis

a) Planar Failure

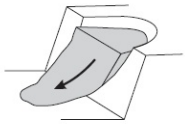




b) Wedge Failure



c) Circular Failure



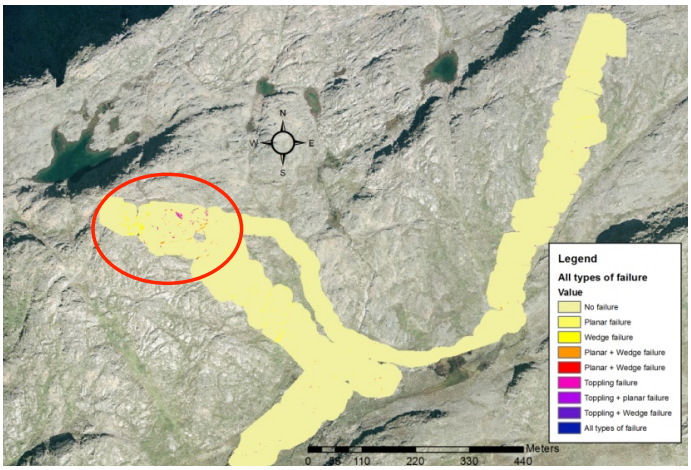
d) Toppling Failure

Analysis and Results

3. GIS-Based Kinematic Slope Stability Analysis

3.3. Results

-The analysis was done separatly for all the different types of failure and all of them could be summarized in the following raster model.

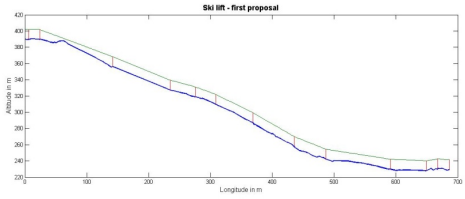


Discussion

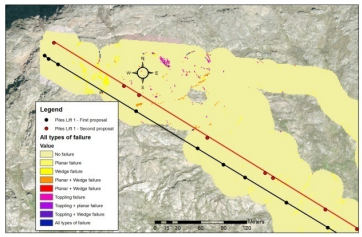
Compliance of the recommendations of the standard DS/EN 12929-1

Ski lift 1 and 2

1. Limitation of the running height above ground (not more than 15m)



2. Observation if the propsed ski lift lines could pass through possible slopes with failure probabilities.

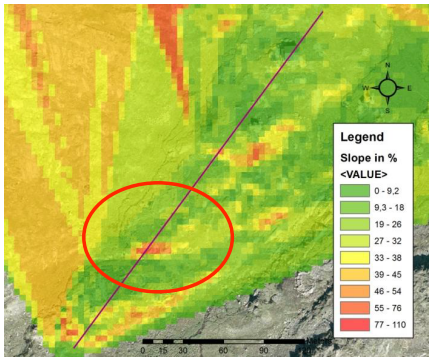


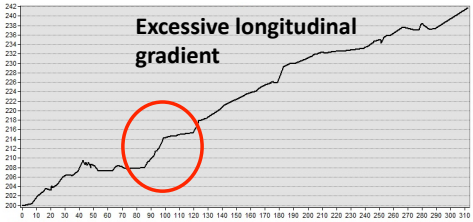
3. Guarantee of the compliance of the clearance envelope and the foot and hand area, as well as analysis of the unloading and loading areas

Discussion

Ski-tow

1. Longitudinal gradient can not exceed 40 % considering the use of tow-hangers and a low level ski-tow. Almost no negative gradient should be present in the ski-tow line.





2. To avoid skiers from sliding away of the ski-tow line, the transverse gradient of it should be less than 10 %, which could be fulfilled along the hole trace.

Conclusion

1. Overall Conclusions

1. ***Digital Elevation Model:***
   - The GPS Survey is a too complex method to obtain altitude data in mountaineous regions
   - Profiles showed that the ski lifts won't cover zones with extreme steep slopes.
   - Unloading and loading areas could be easily defined.

2. ***Geological Survey***
   - Point load index tests have shown a high variability in the results. Nevertheless the strength results are similar to the ones obtained by the geological hammer.

Conclusion

1. Overall Conclusions

2. ***Geological Survey***
   -RMR and Q-Index produced almost similar results.

3. ***Kinematic Analysis***
   - When using the traditional kinematic analysis with stereographic projections a lot of simplifications are done. In this way, GIS-based kinematic analysis is recommended as well as other types of software, which could facilitate this type of analysis.

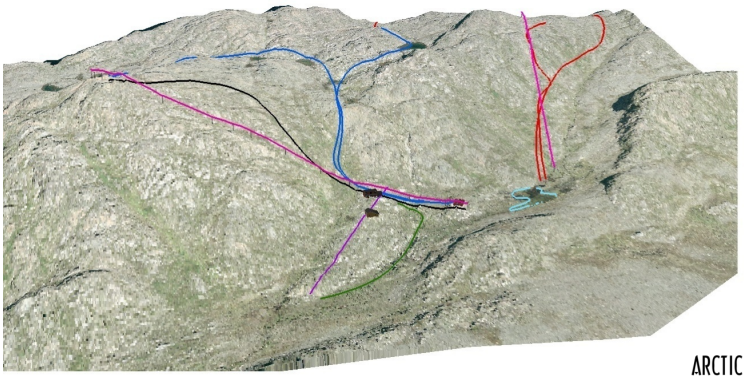
Conclusion

2. Future Perspective

1. ***Spatial Analysis***

   - Other sources to obtain altitude data should be used, like LiDAR

   - A more complete DEM of the whole mountain could facilitate the management of the ski resort as it is already done by other ski stations.



Thank you for your attention!